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Article

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DIET AND PHYSICAL ACTIVITY AS A UNIVERSAL FOUNDATION FOR CHILDHOOD DEVELOPMENT AND LIFELONG HEALTH

Abstract: There is strong evidence that good nutrition and regular physical activity reduce the risk of several short-term health problems like anaemia or obesity, while also preventing long-term diseases such as type 2 diabetes, cancer, osteoporosis or cardiovascular diseases. It is important, however, to analyse this relationship under a holistic approach to the concept of health, which goes far beyond disease prevention and comprises well-being. From this perspective, health can be seen as the condition that allows the individual to express his full potential as a human being, considering its interdependent dimensions: physical, intellectual, emotional, social, spiritual, vocational, financial and environmental. A healthy lifestyle, including not only diet and physical activity, but also sleeping patterns, as well as other factors that have influence on mental and social well-being, is crucial for an optimal child development. The present analysis focuses on children's diet and physical activity as key determinants of health under a life-course approach. We discuss the early origins of health and disease, along with factors associated with the “building” of diet and physical activity habits that set the foundations for lifelong health.

Keywords: diet, physical activity, childhood development, early origins, lifelong health.

Health along the lifespan: the early roots

Scientific evidence from several fields of knowledge such as genetics, epigenetics, developmental biology and epidemiology, shows that the “building” of health has an early origin – the intrauterine life. It is now considered that conditions at the be-

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ginning of development, early *in utero*, may affect the physiology of an organism, which will influence the susceptibility to diseases that may manifest in the long term (Ellison 2010). This relationship was first proposed as the *Foetal Origin Hypothesis* (Barker 1995). Now it is conceptualized as the *Developmental Programming Hypothesis*, which is based on the postulation that environmental influences during critical periods of developmental plasticity may have lifelong effects on the health and well-being of the descendants (Vickers 2014). Epigenetics has become increasingly accepted as the underlying gene-environment mechanism for developmental programming. Although continuously evolving due to different interests and insights (Greally 2018), the term epigenetics (derived from the Greek prefix “epi,” meaning “above” or “beyond”) is attributed to Conrad Waddington (1905-75) who in 1942 used it to describe the “bridge” between the genotype and the phenotype during development (Heard and Martienssen 2014). As a relatively recent field in biology, epigenetics refers to how environmental early-life influences affect gene expression, and ultimately, growth, development, and disease risk, without modifying the underlying DNA sequence (Rhee, Phelan and McCaffery 2012).

Nutritional unbalance, endocrine disrupting chemicals (EDCs) exposure, or stress, are among the perinatal factors that might influence the developmental programming and, subsequently, the trajectory of the foetus/offspring (Padmanabhan, Cardoso and Puttabyatappa 2016). During this period, nutrition and dietary factors have received particular attention from researchers, with obesity being one of the most studied diseases in the field of nutritional epigenetics. As suggested by accumulating evidence, early-life nutritional environment, including the one *in utero*, could modify the predisposition to obesity and metabolic dysfunction in later life through mechanisms affecting the systems that regulate energy balance (Reynolds et al. 2018). The *Healthy Start Study*, carried out with a pre-birth cohort of 826 women, showed that weight gain during pregnancy, regardless of the pre-gestational BMI of the mother, is directly related to the child’s adiposity at birth (Starling et al. 2015). In line with other studies, these results support the above-mentioned link, at the same time that highlight the importance of the mother’s dietary habits and nutritional status during pregnancy in order to promote a normal birth weight. Not only high birth weight new-borns may be at increased risk of developing obesity (Kang et al. 2018) but also low birth weight ones (Jornayvaz et al. 2016), although this last association is not as consistently described in the literature as the first (Schellong et al. 2012).

Breastfeeding and complementary feeding as proximal/distant health determinants

Breastfeeding is undoubtedly one of the most important building blocks for children's health and development. As demonstrated in numerous studies, the benefits of this natural act are vast, extend throughout the life course, and have unequalled biological and emotional repercussions on the health of both child and mother. The various levels at which the effects of breastfeeding are observed include growth over the first year of life, neuro-cognitive development, academic performance and prevention of multiple diseases. Regarding the latter, obesity stands out again. Infants who are breastfed, compared to formula-fed infants, have a 20% reduction in the likelihood of being obese at school age. One of the possible explanations for this association may be that infant formulas induce a higher rate of weight gain in the first months of life, which in turn increases the risk of obesity during childhood (Koletzko et al. 2009; Mook-Kanamori et al. 2011; Wang et al. 2016a). In Europe, despite signs of stabilization in the prevalence of childhood obesity observed in some countries, this is still a major health and societal problem (Miqueleiz, Lostao and Regidor 2016; Rokholm, Baker and Sørensen 2010). See, as example, the remaining high prevalence of overweight (30.7%) and obesity (11.7%) in Portuguese children, though a decreasing trend from 2008 to 2016, based on data collection from the *COSI Portugal* 4th round, have been reported (WHO 2018a).

Beyond being the ideal source of nutrients, human milk has also a crucial role in creating and modelling the infant gastrointestinal microbiota. Several studies indicate that microbiota, particularly gut microbiota, is a driver for health, having a key role in metabolism, immunity, digestive function and nervous system. As such, breastfeeding also contributes for the prevention of allergies, autoimmunity disorders, and metabolic syndrome, diseases known to be related with dysbiosis (Castanys-Munoz, Martin and Vazquez 2016; Davis, Wang and Donovan 2017; Tanaka and Nakayama 2017; Toscano et al. 2017).

The potential link between breastfeeding and educational outcomes has been under the focus of researchers around the world. In a study conducted in the UK (n=5489), a good academic performance level at age 5 was more likely to be achieved by children who had been breastfed for up to 2 months than by those who were not

breastfed (Heikkila et al. 2014). Duration of breastfeeding also seem to be important as the observed association was more marked in children breastfed for 2-4 months and in those breastfed for longer than 4 months. Similar results have been found for children assessed in later ages and in adolescents, with possible gender-related differences yet to be clarified (Nandi, Lutter and Laxminarayan 2017; Oddy et al. 2011). A recent systematic review and meta-analysis reinforces previous evidence, revealing that breastfeeding is related to improved performance in intelligence tests among young people (Horta, Loret de Mola and Victora 2015). The authors of a study conducted in Brazil examined whether this association would be verified even later in life – adulthood. They not only have found that breastfeeding is associated with both improved performance in intelligence tests 30 years later and increased educational attainment, but with better income in adulthood (Victora et al. 2015).

Complementary feeding, another early childhood key determinant for good nutrition, lays the groundwork for the development of eating behaviour and food preferences (Mameli, Mazzantini and Zuccotti 2016). Despite the genetic basis of food preferences, children learn to eat through familiarization, association, and observation (Birch and Douthett 2014; Fildes et al. 2014; Smith et al. 2016; Ulla et al. 2016). Therefore, family dietary habits, along with parenting and feeding approaches, have a decisive role in shaping the home food environment in a way that promotes health. Unfortunately, many childhood eating behaviour and nutrition-related problems have its origin on precisely this environment. Family adherence to healthy traditional diets has been declining in many countries because of profound changes in the food systems. Driven by globalization, trade liberalization and rapid urbanization, this trend parallels that for increasing dietary patterns based on ultra-processed foods. Usually, diets based on this type of foods are low in fibre and nutrient density, as well as high in energy density, sodium, added sugars, processed fats (e.g. hydrogenated fats) and artificial ingredients (Costa Louzada et al. 2015; Kearney 2010; Verger et al. 2018).

The preschool years and beyond: shaping healthy eating habits

As children's diet become similar to that of their family, and social contexts progressively influence eating behaviour and food intake (Higgs and Thomas 2016), it is plausible to consider that the above-mentioned dietary characteristics already affect children's nutrition and health in the preschool/school years. Indeed, this is the case.

Preschool children from most Mediterranean countries of the European Union show low adherence to a Mediterranean-like diet, and a food intake high in sodium and energy density (Pereira-da-Silva, Rêgo and Pietrobelli 2016). Moreover, as concluded by the referred researchers, the unhealthier diets were associated with high prevalence of overweight and obesity at early ages, lower maternal educational level and parental unemployment. Also in a previous study conducted in U.S.A with 2 to 8 year old children, obesity was associated with high dietary energy density, greater intakes of energy, fat and added sugars, along with low fruits and vegetables consumption (Vernarelli et al. 2011). These results are of particular significance, taking into account the potential tracking of dietary habits (whether healthy or not) from childhood into adolescence, and then into adulthood (Movassagh et al. 2017).

Even foods intended for toddlers are great cause of concern. Like the observations from Canadian researchers (Elliott 2011), most commercial meals, cereal bars, breakfast pastries, snacks and desserts specifically available for toddlers in the United States contain added sugars or have high sodium (Maalouf et al. 2017). The recognition of the negative health consequences from the excessive intake of free sugars has lead the World Health Organization to recommend its limitation to less than 10% of total energy intake, suggesting that a further reduction of the intake of free sugars to below 5% of total energy intake could be associated with health benefits (WHO 2018b).

In addition to efforts for reducing free sugars intake, especially those added by the food industry or the consumer, there has been growing focus on the promotion of fruit and vegetable consumption from an early age. This food group, universally recognized as “healthy”, is essential for providing a broad spectrum of nutrients, without which it is not possible to attain an optimal nutritional status during growth and promote health. According to the World Health Organization, a daily intake of fruit and vegetables around 400-600g reduces the risk of cardiovascular diseases, cancer, low cognitive performance and other food-related diseases, as well as prevents micronutrient deficiencies (Rodriguez-Casado 2016). In fact, the latest scientific evidence from clinical and epidemiological research clearly demonstrate the health effects of fruit and vegetables as part of a balanced diet. These effects arise from several nutrients like dietary fibre, which is associated with lower incidence of cardiovascular disease, obesity and type 2 diabetes. Fruit and vegetables are also rich in vitamins, minerals and phytochemicals that function as antioxidants, phytoestro-

gens and anti-inflammatory agents. Together, these nutrients protect against various diseases through several biological mechanisms (Alissa and Ferns 2017; Slavin and Lloyd 2012; Wang et al. 2016b).

“Back to basics” may be an effective way of simultaneously limit the consumption of added sugars and ensure an adequate intake of fruits and vegetables, among other relevant aspects for good nutrition. How to do this? Stopping the loss of healthy and sustainable traditional diets and respective cultural, social and environmental legacy. Examples of these diets, based on fresh, seasonal and local foods, are the Mediterranean, the Nordic or the Japanese diet, for which there is scientific evidence of a correlation with health and disease prevention across the lifespan (Limongi et al. 2017; Olsen et al. 2011; Tada et al. 2011; Yamagishi et al. 2008). By promoting these diets, we avoid losing the knowledge, skills, practices, representations, expressions, places and objects that were created and recreated historically over thousands of years in an intimate relationship between people and nature (Dernini 2011). Thus, beyond the health and environmental benefits, it is important to consider the sociocultural dimension of ancestral diets, which is linked to the identity of each people and sense of belonging.

Physical activity: a vital part of a healthy lifestyle

Physical activity is a multidimensional behaviour defined as any bodily movement produced by the skeletal muscles that results in energy expenditure, with frequency, intensity, duration and type being its modifiable components (Barisic, Leatherdale and Kreiger 2011; Caspersen, Powell and Christenson 1985). In contrast to physical activity, inactivity occurs when body movement is minimal. In this situation, energy expenditure is close to the resting metabolic rate. Watching television, reading, using the computer or talking on the phone are examples of sedentary activities and, like physical activity, different dimensions such as duration and type can be considered.

Socio-ecological models propose that there is a complex interaction between the factors that influence physical activity, such as the individual behavioural characteristics and skills, the physical and sociocultural environment, as well as demographic, biological, psychological, and cognitive-emotional factors (Cohen, Scribner and Farley 2000; Craggs et al. 2011; Sallis, Prochaska and Taylor 2000). During growth, sex and age appear to explain differences observed in the patterns of physical activity. As

described in the literature, boys tend to be more active than girls are (Telford et al. 2016), and children tend to be more active than adolescents are (Dumith et al. 2011; Malina 2001).

Physical activity: broad range of benefits during growth and beyond

In the last decades, along with changes in dietary pattern there have been reports of an increase in sedentary behaviours among young people from many countries (LaFontaine 2008; Mielgo-Ayuso et al. 2017; Ng and Popkin 2012; Saunders, Chaput and Tremblay 2014). This is a concerning shift since it is widely recognized that physical activity is a key determinant for health and well-being at all ages. In adults, systematic reviews and/or meta-analyses have demonstrated an association between physical activity and the prevention of premature mortality, prevention of several chronic diseases, well-being, healthy aging and, possibly, longevity (Daskalopoulou et al. 2017; Reimers, Knapp and Reimers 2012; Stewart, Benatar and Maddison 2015; Warburton and Bredin 2017). Physically active children and adolescents also have important biological and psychosocial benefits. Even modest amounts of physical activity can have health benefits in high-risk youngsters, as for example, obese children (Janssen and LeBlanc 2010). In general, positive effects on body composition, health and well-being should occur if school-age children perform 60 minutes/day or more of moderate-to-vigorous intensity activities with a common denominator: developmentally appropriate, enjoyable and diversified (Strong et al. 2005).

These characteristics call immediate attention to something as spontaneous and important to children as play, particularly free (unstructured) play. While playing in different environments children develop much more than motor skills or fitness. Play contributes to children's development of learning, creativity, imagination, problem solving, as well as cognitive, emotional and social skills (Ginsburg 2007; Moreno 2016). This is fundamental for a harmonious development of the child, which in turn will set the foundations for health, well-being and personal achievement. As suggested by Burdette and Whitaker (2005), in order to promote movement at early ages, the term "play" should be used instead of "physical activity," "exercise," or "sports," because young children have particular ways of being physically active, that differ from older children and adolescents.

Sport is one type of leisure-time regular participation in physical activity that is

known to have positive effects on health, education and behaviour. Although the physical health benefits are those more consistently demonstrated in literature, there has been growing interest in the potential impact on the mental and social components of health (Felfe, Lechner and Steinmayr 2016). In fact, results from a systematic review indicate that participation in sport has many different positive psychological and social health outcomes in children and adolescents, with improved self-esteem and social interaction the most commonly observed, followed by fewer depressive symptoms (Eime et al. 2013). From a life course point of view, understanding the tracking of physical activity across childhood, and into adolescence and adulthood, is very important. Several studies suggest that being physically active during growth, including through sports, increases the likelihood of having a more active lifestyle in adulthood (Aarnio et al. 2002; Makela et al. 2017; Tammelin et al. 2003). Perceived sports competency (in females), cardiorespiratory fitness, playing sport outside school and having active fathers in childhood and adolescence have been identified as the factors positively associated with the persistence of physical activity during the transition period from adolescence to adulthood (Jose et al. 2011).

Physical Activity and Nutrition: the interplay

Physical activity and nutrition are interrelated health determinants. Their interaction regarding health and disease is complex and mediated through several mechanisms. Such an example can be seen in the regulation of appetite and subsequently in obesity prevention or treatment. Contrary to what many might believe, because of an increased appetite sensitivity, regular physical activity improves food intake and energy balance regulation (Perry and Wang 2012). Additionally, physical inactivity triggers overconsumption and appetite dysregulation, which in turn might result in increased adiposity (Hopkins and Blundell 2016). Nevertheless, neither the biological mechanism underlying these associations nor the inter-individual variations observed are yet well understood. From a public health point of view, interventions aimed at improving the food and physical activity environment might have advantages if based on integrated rather than isolated approaches (Economos et al. 2015). Some nutritional education tools have been modified precisely with this propose. The *Mediterranean Diet Pyramid*, in addition to food/nutrition information, now includes a symbol representing the importance of regular physical activity. As stated by its authors, the

new graphics reflect not only the updated dietary recommendations, but the lifestyle, sociocultural, environmental and health challenges posed to the Mediterranean populations (Bach-Faig et al. 2011).

Conclusion

Eating is much more than simply providing nutrients for body functions. Physical activity goes far beyond the movement *per se* or the biological needs of the body. Both are complex behaviours involving the influence of multiple factors interacting at biological, physical and social environmental level, as well as policy level. Although nutrition and physical activity are consensually recognized as major determinants of health, ultra-processed based-dietary patterns and sedentary activities have increased in many countries. Findings from epigenetic studies make evident that the foundations for an optimal development and life-long health are set at early ages, even from the intrauterine life. In turn, this will lay the ground for developing the capacities and abilities that citizens need to have productive lives and to contribute to the prosperity of societies. Therefore, health education, physical education, nutrition literacy and primary health care need to be improved in order to foster healthy lifestyles across all age spectrum. Likewise, policies and regulations on food systems, environmental protection, urban planning, transport, trade, advertising or early care must be rethought under a life course perspective of health. Ultimately, these investments should help shape the “environments” so that the healthiest choices become the easiest ones.

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